Protocol Development Summary
Landscape Dynamics Monitoring Program in the NCCN
April, 2005

Protocol: Protocol to Monitor Landscape Level Change in and around National Parks in the North Coast and Cascades Network.

Current Status of Protocol Development: A protocol for satellite remote sensing based monitoring of change in the National parks of the NCCN is being developed under contract with researchers at Oregon State University. The final protocol will be ready in FY06. Work on a protocol for an Aerial Photography based monitoring program will begin in FY06.

Table 1. Schedule for Protocol development

Activity	LandSat-based Protocol	Aerial Photography Protocol
Pilot field work	FY04	FY06
data analysis methods	FY05	FY06
data design/management	FY05	FY06
protocol writing/adaptation	FY05	FY06
peer review	FY05	FY07
finished product	FY06	FY07

Parks Where Protocol will be Implemented: The protocol will be implemented in all of the NCCN parks.

Justification: Remotely sensed data have the potential to effectively address many monitoring needs in national parks. These include the need to monitor large areas that are inaccessible by foot travel, the need to view some processes from the landscape perspective, and the need to detect unique events (e.g., windthrow in parks due to clearcut logging outside park boundaries). These and other landscape changes can be detected with 30 m resolution satellite imagery that is available at low cost.

Landscape level monitoring through remote sensing provides the context for understanding plot level monitoring results. It allows for inference to park and regional scales. Landscape level changes are important to monitor as they can be considered both system drivers (adjacent land use) and response variables (changes in canopy closure of forested stands due to disease).

Monitoring disturbance and landscape level vegetation patterns were ranked 8th and 9th respectively in the NCCN vital sign priority list. The network ranked disturbance as the 3rd most important driver (after climate and glaciers). The monitoring of landscape level change also supports other protocols such as: extent of snowcover and glaciers; date of ice-out of alpine lakes; subalpine vegetation (esp. meadow-forest ecotone); riparian vegetation (conifer versus deciduous, and total cover); stream habitat (ie. watershed level processes such as mass wasting, channel migration, the distribution of large-woody debris); and recreational impacts (number and extent of social trails, bare ground). Many of these protocols depend on the park-wide coverage of imagery and aerial photography acquired for the Landscape monitoring protocol.

In October of 2002, the USGS hosted a workshop to evaluate the potential for using remote sensing for monitoring natural resources in the NCCN parks (Woodward 2002). The participants in this workshop represented expertise with many different remote sensing techniques. The recommendations of the attendees to the NCCN network parks was to focus on using Landsat or equivalent imagery because of its cost-effectiveness. They also recommended that traditional aerial photography be included in any remote sensing program for natural resource monitoring.

Monitoring Questions and Objectives:

There are many monitoring questions that can potentially be addressed using remote sensing. During the vital signs scoping workshops and the remote sensing workshop previously mentioned, the following questions were identified, which may be at least partially addressed through remote sensing.

1) Are the characteristics of disturbance changing over time with respect to:
    a. Type (Fire, Disease Pathogens, Geologic Process Disturbances, Wind and Storm Events, Flooding, Timber harvest)
    b. Frequency
    c. Size
    d. Spatial patterns
2) Are there large-scale changes in forest composition (such as conifer vs. deciduous)?
3) Is the overstory species composition of the riparian zones changing over time?
4) Is the interface between subalpine and alpine vegetation (treeline) changing position?
5) Are the extents of glaciers and snow fields changing?
6) How is land-use (such as clearing, development, road building) changing around the parks and what affects might this have on the spread of exotic species, habitat fragmentation, water quality, etc.

Preliminary results of pilot work using Landsat imagery, done at the three large parks, as well as near Ebey's landing, have suggested that the methods being evaluated for implementation can successfully detect landslides, avalanche chute clearance, fire, clearcuts, river channel changes, windthrow, and land clearing for rural development, with minimum confusion from radiometric and phenological change. Other work has shown the utility of remote sensing in differentiating between hardwood and conifer (Cohen et al. 1995), detecting changes in snowcover and glacial extent (Dozier, 1989), and distinguishing differences in total cover, conifer cover, crown diameter, and age, in forested communites (Cohen et al. 2001).

Basic Approach:

Landsat TM satellite imagery will be used to monitor landscape scale changes. Image differencing or change vector analysis will be used to identify areas of change annually. Identifying the mechanism of change for each of those areas will be done through either comparing change vectors relative to reference spectral keystones (for example old-conifer, barren ground, young conifer, snow) or using one of several other validation techniques. These validation techniques include satellite-to-satellite (interpretation of change by visually comparing the satellite images from time 1 with time 2). Visual clues, spatial context, and knowledge of the systems being studied allow for direct interpretation of many types of change in land surface conditions. Because other forms of validation will likely not be available on a year-to-year basis, this method will be critical for evaluating many of the changes being monitored

On a larger time step of approximately seven years (depending on availability of imagery – see table 2), a more robust but time-consuming validation method using aerial photographs to supplement the satellite imagery will be used. This requires aerial photography from the same time periods as the satellite imagery. True color or infrared aerial photos at 1:12,000 (1 inch = 1000 feet) if possible or 1:15,840 (1 inch = ¼ mile) will be obtained on a rotating basis for all the parks in the network. See Table 2 for a hypothetical schedule. We plan to enter into an agreement with the Washington and Oregon Departments of Natural Resources to cost-share on routine aerial photography covering the parks and adjacent lands. This will amortize the costs such that those costs will be predictable and consistent year to year.

More expensive ground-based validation will probably only be used when site visits can be combined with other monitoring efforts.

Table 2. A hypothetical schedule for image acquisition for the NCCN parks (this will be dependent on partner agencies project schedules).

NCCN Network Park	Years 1, 8…		Years 2, 9…		Years 3, 10…		Years 4, 11…		Years 5, 12…		Years 6, 13…		Years 7, 14…	
	LANDSAT	**Aerial Photos**	**LANDSAT**	**Aerial Photos**	**LANDSAT**	**Aerial Photos**	**LANDSAT**	**Aerial Photos**	**LANDSAT**	**Aerial Photos**	**LANDSAT**	**Aerial Photos**	**LANDSAT**	**Aerial Photos**
EBLA	X	X	X		X		X		X		X		X	
LEWI	X		X	X	X		X		X		X		X	
FOVA	X		X		X	X	X		X		X		X	
SAJH	X	X	X		X		X		X		X		X	
MORA	X		X		X		X	X	X		X		X	
NOCA	X		X		X		X		X	X	X		X	
OLYM	X		X		X		X		X		X	X	X	

Products:

Annual change maps. Annual changes in forest structure, coniferous versus deciduous trees, and trees versus meadows; identify areas experiencing catastrophic disturbance; annual changes in land use and land cover, especially in areas surrounding parks; changes in areas covered by snow and glaciers.

Approximately every seven years a more detailed, validated analysis will be produced for each park (where relevant) including: trends in forest structure, composition (coniferous versus deciduous), and extent (forest versus meadows); trends in occurrence of types of catastrophic disturbance; trends in land use & land cover, especially in areas around parks; trends in snow cover & glaciers. Complete aerial photography coverage of each park to support other protocols.

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Development Schedule, Budget, and Expected Interim Products: The protocol for satellite remote sensing based monitoring of change in the National parks of the NCCN will be written by the contractor and finalized by 2006. Products associated with protocol development include: 1) a peer reviewed final protocol that outlines monitoring objectives, sampling design, and methods for monitoring landscape change in the NCCN using Landsat imagery; 2) SOPs for image processing, analysis and validation. The protocol will meet NPS standards and will be developed in accordance with Oakley et al. (2003). The goal is to implement the protocol in 2006. The estimated annual cost of implementation is $49,280/year depending mostly on aerial photography contracts and cooperators. Protocol development is being funded by USGS-BRD ($181,117) and NPS (through OLYM, $10,000). (Note: processing and analysis of TM imagery are assumed to be performed by permanent GIS personnel supported by network funds.)

Table 3. Landsat Image Path/Row designation required for each park in the NCCN network.

	Path 48	Path 47	Path 46
Row 26	OLYM	SAJH EBLA	NOCA
Row 27		OLYM	MORA
Row 28		LEWI	FOVA MORA

Table 4: NCCN Landscape Dynamics Budget

Salaries and Benefits	Job component	PP	Cost
GS9 Permanent STF	Image Processing (OLYM?)	2	4183
GS9 Permanent STF	Interpret Changes (MORA)	1	2091
GS9 Permanent STF	Interpret Changes (NOCA)	1	2091
GS9 Permanent STF	Interpret Changes (OLYM)	1	2091
GS9 Permanent STF	Photo Interpret (MORA)	1/7years	300

GS9 Permanent STF	Photo Interpret (NOCA)	1/7years	300
GS9 Permanent STF	Photo Interpret (OLYM)	1/7years	300
			$11,356

Imagery		
Landsat Imagery	7 scenes/year @ approximately $600/scene	4200
Aerial Photography	7 year rotation – all parks	32,500
		36,700

Supplies and Equipment	
Plotter paper, archival supplies for photographs, media for archiving data	**$1,224**

GRAND TOTAL = **$49,280**

* Salaries based on 2005 OLYM tables.
GS 9 calculated as current cost for existing personnel (step 5)

References

Cohen et al. (Cohen, W. B., T. A. Spies, et al. (1995). Estimating the age and structure of forests in a multi-ownership landscape of western Oregon, U.S.A. International Journal of Remote Sensing **16**: 721-746) and other studies.

Cohen et al. 2001 (Cohen, W. B., T. K. Maiersperger, et al. (2001). Modeling forest cover attributes as continuous variables in a regional context with Thematic Mapper data. International Journal of Remote Sensing **22**: 2279-2310)

Dozier, J., 1989. Spectral signature of Alpine snow cover from the Landsat Thematic Mapper. Remote Sensing of Environment, 28, 9-22.

Oakley, K. L., L. P. Thomas, and S. G. Fancy. 2003. Guidelines for long-term monitoring protocols. Wildlife Society Bulletin 31(4):1000-1003.

Woodward, A., S. Acker and R. Hoffman. 2002. Use of Remote Sensing for Long-term Ecological Monitoring in the North Coast and Cascades Network: Summary of a Workshop.